The Exact Solution of the Einstein Equations Without Singularities and the Experimental Tests the Existence of Black Holes*

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Abstract

It is shown that the new revised solution of Schwarzschild's problem, presented in gr-qc/9905068, does not contain singularities and black holes for some values of the new free parameter of the Einstein theory. After determining a value of the parameter from second order terms of standard gravitational effects, we can conclude about the existence or nonexistence of black holes and singularities. The preliminary results show that the horizons can be appear for macroscopic objects and they can not formed in case of microscopic particles, while the singularities can not exist in the both cases.

1 General solution with and without singularities

The new general form for the spatially symmetric static line element of a mass point in the Einstein theory at the rest frame of this mass is [1] :

$$ds^2 = (1 - \frac{r_g}{r+\rho})c^2dt^2 - (r+\rho)^2(d\vartheta^2 + \sin^2\vartheta d\varphi^2) - (1 - \frac{r_g}{r+\rho})^{-1}dr^2 \tag{1}$$

In the preceding paper I considered (by use the method of the paper [3]) the particular form of Eq.(1) with $\rho = r_g$:

$$ds^2 = (1 + \frac{r_g}{r})^{-1}c^2dt^2 - (r+r_g)^2(d\vartheta^2 + \sin^2\vartheta d\varphi^2) - (1 + \frac{r_g}{r})dr^2 \tag{2}$$

We see also that the new solution Eq.(1) gives the standard Schwarzschild' solution with black holes at the value $\rho = 0$.

It is a surprise that the new solution in Eq.(1) is *free from the singularities at* $r = 0$ at the values $\rho > 0$. In this case we have:

$$ds^2 = (1 - \frac{r_g}{\rho})c^2dt^2 - \rho^2(d\vartheta^2 + \sin^2\vartheta d\varphi^2) - (1 - \frac{r_g}{\rho})^{-1}dr^2 \tag{3}$$

and the determinant of the metric is regular at the origin ($\sin\vartheta \neq 0$):

$$\sqrt{-g} = (\rho^2 \sin\vartheta) \neq 0 \tag{4}$$

The singularity at the gravitational radius is fictive and can be excluded since the determinant of the metric is also regular at this value of the radial coordinate ($r = r_g$):

$$\sqrt{-g} = (r_g + \rho)^2 \sin\vartheta \tag{5}$$

Therefore, the value of the new free parameter of the Einstein theory ρ determines what kind of situation is realized in nature - with or without singularities and black holes.

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The physical nature of this new parameter ρ is not clear from the framework of the standard Einstein theory, but some hypothesis can be considered in the version of this theory with the new solution of the problem of gravitational energy [2] . In this treatment one of the components of 4-index gravitational energy of vacuum for line element Eq.(1) is:

$$V_{0101} = \frac{r_g}{\kappa(r+\rho)^3} g_{00} g_{11} = \frac{mc^2}{4\pi(r+\rho)^3} \tag{6}$$

and at $r = 0$:

$$V_{0101} = \frac{mc^2}{4\pi\rho^3} \tag{7}$$

Our new parameter ρ determines here the energy density of the gravitation at the origin and at $\rho > 0$ the gravitational energy of the point mass is regular. The possible mechanism of excluding a black hole formation can be some connections between the rest energy of the origin and the vacuum energy at this point.

It is important that the parameter ρ does not a trivial translational parameter such as $\mathbf{a} \cdot \nabla(1/r)$ which can be excluded by the shifting of the coordinate system. In our case shifted *only* the radial coordinate, while in the translations the angular coordinates transformed also.

2 The experimental tests

The possibility of the gravitational collapse and the existence of black holes can be tested by the measuring the second order contributions to the standard gravitational effects. These corrections we obtain according to Eq.(1) from the simple modification of the Newton potential $\varphi(r)$ in the metric :

$$g_{00} = 1 + \frac{2\varphi_{(\rho)}(r)}{c^2} + \beta \frac{2\varphi^2_{(0)}(r)}{c^2} \tag{8}$$

where $\beta = 1$ in the general relativity, and the modified Newton potential is:

$$\varphi_{(\rho)}(r) = -\frac{km}{r+\rho} \tag{9}$$

Then we have:

$$\frac{2\varphi_{(\rho)}(r)}{c^2} = -\frac{2km}{rc^2}(1-\frac{\rho}{r}) = \frac{2\varphi_{(0)}}{c^2}(1-\frac{\rho}{r_g}\frac{r_g}{r}) = \frac{2\varphi_{(0)}}{c^2}(1-\rho_0\frac{2km}{rc^2}) = \tag{10}$$

$$= \frac{2\varphi_{(0)}}{c^2}(1+\rho_0\frac{2\varphi_{(0)}}{c^2}) = \frac{2\varphi_{(0)}}{c^2} + 2\rho_0\frac{2\varphi^2_{(0)}}{c^4} \tag{11}$$

where:

$$\rho_0 = \frac{\rho}{r_g} = \frac{\rho c^2}{2km} \tag{12}$$

Therefore, our new second order term leads to a shifted value of the parameter β in the standard second order terms and as result we have:

$$g^{(\rho)}_{00} = 1 + \frac{2\varphi_{(0)}(r)}{c^2} + \beta_{(\rho)}\frac{2\varphi^2_{(0)}(r)}{c^2} \tag{13}$$

with $\beta_{(\rho)} = \beta + 2\rho_0 = 1 + 2\rho_0$.

For the standard Schwarzschild solution with singularities and black holes $\rho_0 = 0$ and $\beta_{(0)} = 1$.

At the values $0 < \rho_0 < 1$ and $1 < \beta_{(\rho)} < 3$ the theory is free from the singularities, but the horizons can be appeared.

If $\rho_0 \geqslant 1$ and $\beta_{(\rho)} \geqslant 3$ the horizons disappear and the black holes does not exist in nature.

The experimental value of the parameter $\beta_{(\rho)}$ which obtained from the perihelion shift data is [4] :

$$| 1 - \beta_{(\rho)} | < 0.003 \tag{14}$$

and therefore:

$$\rho_0 < 0.003 \tag{15}$$

At this value of ρ_0 the horizons and black holes exist, but the singularities can be excluded.

As the lowest limit for ρ we can suppose the Compton length $r_c = \hbar/mc$. In this value of ρ we obtain $\rho_0 \geqslant 1$ for the sources with $m \leqslant m_{pl}$, where m_{pl} is the Planck mass. This means that such microscopic objects can not collapsed.

P.S. After the submission of the first version of this paper S.Antoci informed me about a very interesting paper by A.Loinger [5] where the line elements Eq.(1)-(2) are presented as the results of some static coordinate transformations, i.e. found from a geometric point of view. I obtained the line element Eq(1) from the dynamics as the general exact solution of the field equations in the rest frame of the point mass and the coordinate system with the center at the origin. Only in this coordinate system the solution describe the true physical picture of the field and all another coordinate systems introduced into this picture additional (physically unsufficient) kinematical and geometrical effects only. I thank S.Antoci, A.Bossard, N.Obadia and L.Lehner for their useful discussion.

References

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